It is entitled "Smut Diseases of Cultivated Plants, Their Cause and Control," and was prepared by the Dominion Botanist, Mr. H. T. Güssow. In somewhat less than sixty pages the author presents in fairly non-technical language the important facts about smut fungi in general, followed by details regarding ten species which attack wheat, barley, oats, corn, broom corn, and millet. In an appendix the latter are described botanically for the benefit of students. Good figures, which are freely used, help both the farmer and the student to identify the diseased hosts, as well as the parasitic fungi. Preventive and remedial measures are suggested at every step. The importance of such a bulletin may be appreciated when we remember that it is estimated that Canadian farmers annually lose about $15,000,000 from the ravages of these smuts.

BOTANISTS and foresters will be glad to know that Professor A. F. Blakeslee and his colleague, C. D. Jarvis, have reprinted the Keys to the Genera and Species of Trees in the Eastern United States. These were originally in their book "Trees in Winter," and the many requests from teachers and others for separate copies of these keys have induced the authors to issue them in a 15-page pamphlet. It may be obtained of the authors at Storrs, Conn., for 30 cents, and should prove helpful to teachers who are trying to teach their pupils how to know the names of the trees about them.

SOME months ago there came to hand the Annual Report of the Agrostologist and Botanist of the Transvaal for the year 1911, bearing date of June, 1912, but issued later from the press. It was prepared by Professor J. Burtt-Davy, the well-known botanist of south Africa, and contains many items of considerable botanical interest, especially to those whose interest extends to applied botany. A large part of the paper is devoted to a discussion of the plants suspected of being poisonous to cattle ("lamziekte").

AMONG recent contributions from the United States National Herbarium (Volumes 16 and 17) are the following: Cook and Doyle's Stilt Palms (*Iriartineae*), describing three new genera; Britton and Rose's Studies in Cactaceae, in which they describe seven new species from Mexico, Guatemala and Panama; Cook's Relationship of *Pseudophoenix,* a curious relative of the Date Palm; Britton and Rose's Genus *Epiphyllum,* in which two new genera and five new species are described from Mexico and southward: Smith and Rose's Monograph of certain tribes (Hauyeae and Gongylocarpeae) of the Onagraceae, represented by Mexican and Californian genera; Maxon's Fourth instalment of his Studies of Tropical American Ferns, containing notes on *Asplenium trichomanes, Dicksonia, Odontosoria,* and other fern genera, and new species of *Lycopodium;* Hitchcock's Mexican Grasses in the U. S. National Herbarium, including 133 genera and 613 species. The large genera are *Muhlenbergia* (58 species), *Panicum* (54 sp.), *Paspalum* (39 sp.), *Andropogon* (28 sp.), *Bouteloua* (28 sp.), *Sporobolus* (21 sp.), *Eragrostis* (21 sp.), *Aristida* (19 sp.) and *Stipa* (16 sp.). Six bamboos are enumerated.

The Contributions from the Gray Herbarium of Harvard University (N. S., XLII.) include critical studies of certain genera of Composites, and a report upon the grasses collected in British Honduras by Professor M. E. Peck.

CHARLES E. BESSEY
UNIVERSITY OF NEBRASKA

SPECIAL ARTICLES

MITOCHONDRIA IN TISSUE CULTURE

THE immense literature[1] which has grown up in the last few years, concerning these minute bodies found in the cytoplasm of various cells in many different species not only of vertebrate and invertebrate animals but also of plants, and the great importance which has been assigned to them by various authors must necessarily arouse even more general interest and increased observation and discussion.

A multiplicity of names has already been given these bodies: mitochondria and chon-

[1] J. Duesberg, *Ergebnisse der Anatomie und Entwickelungsgeschichte,* Bd. XX., 1911.

driomiten by Benda; chondrioconten, chondriosomen, chondrion and plastosomen by Meves; plasmafaden, plasmaköner by Retzius; paramiton or miton by Flemming; microsomen by Van Beneden; granule and filament by Altmann.

The mitochondrial theory has been most widely promulgated by Benda (1899–1903) and Meves (1907–1908). Duesberg states the theory concisely as follows: the mitochondria are specific elements of the cytoplasm, which arise from preformed elements in the male and female sex cells and are carried over into every cell at mitosis. These bodies differentiate into specific parts of the various adult tissues. While there are many authors whose observations tend to substantiate the mitochondrial theory, on the other hand just as many writers refuse to accept the mitochondrial theory in its entirety. Some give observations to show that the mitochondria are formed from nuclear material at certain periods of the cell's activity.[2] Others claim that they are fermentation products of the activity of the centriole,[3] and still others state that the mitochondria are throughout entirely different elements whose identity have nothing in common.[4]

The tissues from chick embryos grown outside the body in media of known chemical constitution, which we have been studying during the past three years, with other problems in mind, have shown such beautiful mitochondria in both fixed and living specimens that we are led to believe this method offers a better opportunity for their study than any heretofore used.

Small pieces of tissue from a chick embryo, four to ten days old, suspended in a drop of Lock's solution containing 0.25 per cent. dextrose are placed on the sterile surface of a clean coverslip. The coverslip is then inverted over a hollow ground slide, sealed with vaseline, and incubated at 39° C.; growth usually appears at the end of 10–20 hours. Such preparations are studied on the warm stage with the No. 2 Zeiss apochromatic and a No. 4, 6 or 8 ocular.

Janus green in strengths of .00001 and .000005 of 1 per cent. stains the mitochondria in the living cells a brilliant blue green. The color fades, however, in from 15 minutes to 3 hours, and we have been unable to restain. The janus green is also slightly toxic and kills the cells in a few hours. We are indebted to Dr. E. V. Cowdry for this particular janus green (di ethyl saffranin azo di methyl aniline) which was obtained by him from Dr. Bensley of Chicago. Attempts to stain with another make were unsuccessful.

Nilblew B. extra, for which we are indebted to Dr. Herbert Evans, was used in very dilute solution of .000005 to .0000025 of 1 per cent. for the detection of lipoids in connection with the mitochondria. It stains the lipoids pink, but is unfortunately somewhat toxic and, like the janus green, kills the cells in a few hours.

The preparations are fixed by placing the coverslip in a chamber of osmic acid vapor from two to five minutes and since the growth is very thin, the fixation is almost instantaneous and the mitochondria remains practically the same as in the living cells. The blackening caused by the osmic is bleached during the hardening processes by means of a few drops of hydrogen peroxide in the 70 per cent. alcohol and the preparations are then stained with Heidenhain's iron hematoxylin. Since in places the cells are flattened out on the under surface of the coverslip into a single layer much thinner than the usual thickness of a single cell, one can study the entire living cell and its contents with a minimal amount of focusing. Also at any moment during the observations the culture can be fixed and later the same cells studied in a stained preparation.

Mitochondria were studied in endothelium, mesenchyme, giant cells, ectoderm, heart muscle, smooth muscle and endoderm.

The stained preparations show great variety in the shape of mitochondria and often in the same specimen, as of heart muscle or mesenchyme, all the so-called types described by

[2] R. Hertwig and Goldsmith, 1909.

[3] Vejdovsky, 1907.

[4] Veratti, 1909; Pensa, 1911; Linidegard, 1910; Curwitsch, 1910.

other observers are to be found. In such specimens, granules, rods, threads, loops and networks can be arranged in a continuous series; in other words, there are to be found in single stained preparations all gradations of size and shape from the small and large granules to short rods and long rods, to threads of varying length, to anastomosing threads and networks, which extend throughout the cytoplasm and to rings and loops of various shapes.

Certain kinds of cells do, however, contain characteristically shaped mitochondria. Intestinal or stomach endoderm shows only granules and short rods. Heart and smooth muscle cells contain in addition to the usual types large round and spindle-shaped mitochondria. In the heart muscle cell the appearance of the central body, probably the centrosome, at the base of the nucleus, is much more definite than in most cells. The mitochondria radiate out from this central body as though under the influence of the activity of the centrosome, as is believed by Vejdovsky.

By far the most important and interesting are the observations on the living cells. In the living cells the mitochondria are seen as slightly refractive opaque bodies. They can be studied from minute to minute over a period of several days if necessary. The mitochondria are almost never at rest, but are continually changing their position and also their shape. The changes in shape are truly remarkable not only in the great variety of forms, but also in the rapidity with which they change from one form to another. A single mitochondrium may bend back and forth with a somewhat undulatory movement or thicken at one end and thin out at the other with an appearance almost like that of pulsation, repeating this process many times. Again, a single mitochondrium sometimes twists and turns rapidly as though attached at one end, like the lashing of a flagellum, then suddenly moves off to another position in the cytoplasm as though some tension had been released. Corresponding to the forms observed in the stained preparations we find in the living that granules can be seen to fuse together into rods or chains, and these to elongate into threads, which in turn anastomose with each other and may unite into a complicated network, which in turn may again break down into threads, rods, loops and rings.

The mitochondria in a cell of a living preparation of a piece of heart of a five-day chick embryo studied on the third day after the culture was made presented a very remarkable picture. Radiating out from the central body at the base of the nucleus were numerous granules, rods and thread-like mitochondria. They were seen to elongate to many times their original length, spreading out through the cytoplasm and to anastomose into a complicated network. About fifteen minutes later this network broke up and contracted into threads, rings, loops and rods and granules. This entire process took place without any noticeable change in the position or size of the cell.

The presence of fat is shown by the Nilblew vital stain within the varicose mitochondria. We have not observed any connection between the disappearance of mitochondria and the formation of fat within the cell as stated by Dubreuil.

The question as to whether the mitochondria divide, so that one half of each mitochondrium passes into each daughter cell at mitosis (Benda), is one of the most interesting in the whole field of work upon mitochondria. As yet we are unable to state definitely that such a division takes place. In the cells of the tissue cultures the behavior of the mitochondria is difficult to follow during mitosis, since the body of the cell contracts to much less than the normal size and its processes become exceedingly long and delicate. All of the mitochondria are drawn into the body of the cell and become very short dumb-bell-shaped granules during the late metaphase and anaphase. Owing to the very flat shape of the cells (growing along the coverslip) the spindle always appears horizontal to the coverslip and the plane of cleavage perpendicular to the surface. In some cells during the anaphase the mitochondria were observed to collect in a zone through which the cleavage plane will

later pass, and about equal parts of the mass of mitochondria were included in each daughter cell. In other cells no such definite behavior of the mitochondria takes place. They remain scattered throughout the cytoplasm or are collected at the two poles of the cell during the formation of the daughter cells.

The question of the behavior of the mitochondria during the life history of the cell is one of great interest and we feel confident that this method of study of the living cell will be of great value not only for making observations upon the mitochondria, but also for the study of other activities of the cell.

Can we infer from these observations anything concerning the real nature of the mitochondria? Are they organs of the cell, functioning in a definite manner, in other words a living part of a living cell? If they are organs of the cell, are they concerned in the routine metabolism which takes place in all living cells or are they concerned with the process of differentiation of such structures as the myofibrillæ, neuro-fibrillæ, white fibrous tissue, etc.? On the other hand, are we dealing with inactive metabolic products of the cell, inactive in the sense of not being a part of the living protoplasm? If so, are they excretory products which later are extruded from the cell or storage products which are being continually formed by the activity of the cell and again used up in its metabolism? What relation do they bear to the metabolism of the nucleus, if any? The discussion of these most important points must be left for a more complete account of the mitochondria in tissue cultures which is soon to follow.

M. R. LEWIS,
W. H. LEWIS
JOHNS HOPKINS UNIVERSITY

ASTRONOMICAL AND ASTROPHYSICAL SOCIETY OF AMERICA

THE sixteenth meeting of the Astronomical and Astrophysical Society of America was held in Atlanta, Ga., in connection with the American Association for the Advancement of Science on December 29, 1913, to January 1, 1914. The general social features of this meeting participated in alike by the association and the affiliated societies have already been described by the general secretary of the association.

In connection with the relation of this society to the association one matter may be mentioned. Following the adoption of the plan for large general quadrennial meetings the society voted to endeavor to meet with the association for these meetings.

The council elected the following persons to membership: The Rev. T. H. E. C. Espin, Tow Law, Co. Durham, England; Dr. C. C. Kiess, Laws Observatory, Columbia, Mo.; and to honorary membership, Professor G. F. J. Arthur Auwers, Bellevuestr. 55, Grosslichterfelde, Berlin, W., Germany.

The following members were in attendance: G. C. Comstock, W. S. Eichelberger, Philip Fox, C. H. Gingrich, C. S. Howe, W. J. Humphreys, F. R. Moulton, E. C. Pickering, W. F. Rigge, H. N. Russel, Frederick Slocum; and the following visitors from the association: William Bowie, S. M. Barton, E. B. Van Vleck, C. F. Emerson, and R. P. Stephens.

At the joint meeting with Section A of the association two admirable addresses were delivered. The retiring vice-president of the section, Professor E. B. Van Vleck, presented "The Influence of Fourier's Series upon the Development of Mathematics." The society was represented by Professor H. N. Russell, who spoke on "Relations between the Spectra and Other Characteristics of the Stars."

Aside from these two addresses the scientific program contained twenty-nine papers and a report from the committee on photographic astrometry. The titles are given below in the order of presentation.

"The Arlington Time Signals in Omaha," by W. F. Rigge.

"Astronomical Panoramic Views from a City Observatory," by W. F. Rigge.

"Micrometric Observations of the Holden and Küstner Double Stars," by Philip Fox.

"Note on the Present Spectra of Three of the Novæ," by W. S. Adams and F. G. Pease.

"Note on the Relative Intensity at Different Wave-lengths of the Spectra of Stars having Large and Small Proper Motions," by W. S. Adams.

"Memoir on the Theory of Orbits," by F. R. Moulton.

"Faint Standards of Photographic Magnitude for Selected Areas," by F. H. Seares.

"Temperature, Rainfall and Sunspot Records," by W. J. Humphreys.